THE

# THEORY

OF

# CHIMNIES AND FIRE-PLACES

## *INVESTIGATED*;

THE PRINCIPLE OF THOSE RECOMMENDED BY

COUNT RUMFORD,

FULLY EXPLAINED, AND THEIR CONSTRUCTION IMPROVED:

AND

A GREAT IMPROVEMENT,

*ON A PRINCIPLE VERY LITTLE KNOWN, AND IN A MANNER NEVER PRACTISED.*

TO WHICH IS ADDED,

A METHOD OF PREPARING HOUSES AND SHIPS, AT LITTLE EXPENCE, IN SUCH A MANNER, THAT, IN CASE OF FIRE, IT MAY BE EXTINGUISHED WITH THE UTMOST EASE AND CERTAINTY.

By THOMAS DANFORTH, Esq.

*Formerly a Fellow of the Corporation of Harvard University, at Cambridge, in America.*

*LONDON:*

PRINTED FOR T. HEPTINSTALL, NO. 131, FLEET STREET.

1796.

THE

# *THEORY*

OF

# CHIMNIES AND FIRE-PLACES INVESTIGATED.

IN this Enquiry, I ſhall endeavour to imitate the plain and conciſe manner of that diſtinguiſhed philoſopher, Dr. Franklin; and, in conformity to the ſame example, avoid the uſe of plates and figures, by referring to common facts, and the moſt ſimple experiments, but, as I hope, in ſuch a manner as to comprehend every part of the ſubject.

Philoſophers, although in general moſt intereſted in domeſtic conveniences, muſt ſurely have aſſociated the idea of a ſweep, or they never could have neglected to ſettle the principles of this very material ſubject; or, perhaps, being abſorbed in their more ſublime literary purſuits,

may have ſo much neglected to cultivate domeſtic attachment as to produce an evil ſo much greater, that the ſmoke has proved an inconvenience perfectly trifling in the compariſon.

Having at different times, for many years, turned my thoughts to this ſubject; the appearance of Count Rumford's Fourth Eſſay, naturally engaged my attention.

Theſe Eſſays having obtained, from the circumſtances of the times, and their real merit, a conſiderable degree of attention; and it appearing from this laſt, that many are conforming to his directions, with regard to fire places; the opportunity appeared ſo favourable, that I determined to attempt the farther explanation of a ſubject, which, ſtrange as it may appear, has generally been conſidered as myſterious.

Since every perſon who publiſhes, muſt of courſe ſubmit to any fair diſcuſſion of the merits of his publication; I need not feel the ſmalleſt difficulty in beginning with a few quotations from the Count's Eſſay, in order to remove, in ſome degree, the charm of his eloquence, and enable the reader the better to judge, whether there is room for farther enquiry; when, if it ſhall appear that

that the Count's imagination ſometimes outſtrips his attention, I may then, without farther introduction or apology, proceed in my inveſtigation of the ſubject, with the Count himſelf ſmiling at his own inadvertencies; and at the ſame time convinced, I hope, that my ſuppoſition, that ſuch a ſtep is neceſſary, is in effect the higheſt compliment I could pay him. If it has the conſequence, in any degree, to improve the remaining Eſſays, the public will reap the advantage, and I ſhall in that reſpect at leaſt have been uſeful.

Page 299. "We are aſſured that the whole myſtery of curing ſmoking chimnies is compriſed in this ſimple direction—Find out thoſe local hindrances which forcibly prevent the ſmoke from going up the chimney, and remove them."

Page 300. "The Count proves that his conſtruction anſwers equally well for wood or coal, by ſhewing, that above a hundred and fifty he has altered in London, for coal only, anſwered perfectly well."

Page 308. "The throat of the chimney ſhould be in its proper place; that is to ſay, in that place in which it ought to be; and all means which can be employed to facilitate the aſcent

of

of the ſmoke, naturally tend to prevent the chimney from ſmoking."

Page 311. "The rays which are ſent off by burning fuel, in paſſing through air, certainly do not communicate *any heat* to it, becauſe the air is tranſparent;"—of courſe glaſs cannot be warmed.

Page 319. "Thoſe bodies which are leaſt heated by the rays, evidently abſorb the leaſt, and conſequently reflect the moſt radiant heat; and hence it appears, that iron, and metals of all kinds, which grow very hot, are the worſt materials poſſible to employ in the conſtruction of fire places;"—of courſe, wood reflects more heat than ſilver.

Page 320. "It is impoſſible to conceive how the heat exiſting in the metal, compoſing any part of the apparatus of the fire place, and ſituated within its cavity, can come, or be brought, into the room; becauſe the heat *actually thrown off* is not increaſed by being thrown off." In page 314, we are promiſed a great improvement hereafter, on this inconceivable principle.

Page 339. "A ſingle coal which falls upon the hearth, ſoon ceaſes to be red hot, being cooled by the ſurrounding cold air of the atmoſphere."

phere." So, page 340, fire ſtone is directed to be uſed to confine the heat, that the fire may not get cold, perhaps; although when there are many in the grate, they keep themſelves warm, in ſome degree, by ſnuggling together like the pigs.

Acknowledging the Count's activity, ingenuity, and philanthropy; but having ſhewn, as I think, that he has too many irons in the fire, I now proceed on my dry and ſmoky ſubject; firſt calling to the reader's recollection a few ſimple facts, which, having been explained and well underſtood, the theory of chimnies and fire-places will, I preſume, be intelligible and obvious.

Every perſon muſt have obſerved, that when a ſmall ſtream, or ray of light, is admitted by a ſmall hole into a darkened room, the ſmalleſt motion in any part of that room, will cauſe the light duſt to be ſeen in motion, in all directions. If a perſon walks acroſs the room, the air forms a current in the ſame direction; and afterward, being reflected by every protuberance in the ſides of the room, and by the furniture, is thrown into as many different currents, in innumerable directions. This ſame irregularity and intermixture of currents, from ſimilar cauſes, is obvious in the ſmoke ariſing from the top of a chimney, which does

does not, for a moment, preſerve the ſame figure or direction.

It is very common for the ſmoke from the chimnies to deſcend into the ſtreets, and it is properly conſidered as a ſign of rain; for it ſhews that the atmoſphere is become ſo light, that the tendency of the lighter ſmoke, and hot air to riſe into it, is not ſo ſtrong as to balance thoſe irregular currents or eddies of air made by the houſe, the top of the chimney, and other ſurrounding bodies. For let us ſuppoſe the wind to be at eaſt, and to blow at right angles againſt the ſide of the houſe, it is plain that the air muſt be there condenſed, in proportion to the force or velocity of the wind; and, accordingly, we find it difficult, ſometimes, to paſs around the corner of the houſe, in oppoſition to it. There would be the ſame difficulty on the top of the houſe. Now this condenſed air paſſing over the houſe and chimney, and condenſing the neighbouring air, ſtill continues to return to a natural ſtate, by expanding in every direction. When finding the air in the ſtreet leſs denſe, it deſcends, and carries the ſmoke with it; and, from the ſame cauſe, down the chimney ſometimes. But when the chimney has a good draught, as it is called, and there is a good clear fire in it, we find the ſmoke

to

to riſe with ſo much velocity, as to paſs this eddy upward, get out of its bounds, and aſcend as uſual.

At the ſame time that the ſmoke deſcends into the ſtreet, with the wind at eaſt, if we open a window of a room, on the weſtern ſide of the houſe, we often find, that the ſmoke will deſcend the flue of that room, and paſs out of this open window to leeward, there being on that ſide of the houſe a deficiency of air; juſt as by the motion of a boat, the water is accumulated at the head, and a vacancy or hollow left at the ſtern. So we often find, that with the wind at eaſt, as before ſuppoſed, if there is a fire in an eaſtern room, and the chimney ſmokes, in conſequence of the condenſed air at the top, paſſing down the flue by expanſion, or in conſequence of an irregular current, cauſed by an adjoining building, if we open a window of this room, the chimney will ceaſe to ſmoke, for the time; but if inſtead of this, we open a window of a weſtern room, and leave open the doors between the two rooms, the eaſtern chimney will ſmoke much more than before, for the wind then paſſes down the chimney, through the rooms, and out at the weſtern window, from the principle juſt explained.

The cauſes of irregular blaſts and eddies, which at times force the ſmoke down chimnies, are infinitely various, according to the ſituation and circumſtances of neighbouring buildings and grounds, but it would be uſeleſs to enumerate them, if poſſible; they can ſeldom be removed, and the remedies are always the ſame.

Moſt perſons muſt have obſerved, at a bonfire, on a plain ſpot of ground, that as the fire increaſed, the velocity of the flame and ſmoke upward, increaſed with it; and in cold weather particularly, a current of air is always felt, from all quarters, toward the fire: and this moſt ſenſibly near the ground. This current getting within the heat of the fire, turns gradually upward, and then riſes in a diſtinct column, within the colder air, as in a chimney. That this column muſt be chiefly ſupplied from near the ſurface of the ground, is evident; becauſe the air, in that ſituation, is moſt compreſſed by the ſuperincumbent atmoſphere. The natural ſagacity of the American ſavages points out this circumſtance; and, in conſequence, they make a fire at night, and placing round it branches of trees, to a conſiderable height, lay themſelves upon them in a circle, around the fire, with their feet directed to it, and thus wrapped up in their blanket, wiſh for nothing ſo much as a plentiful ſnow to cover them; their feet,

feet, however, being conſtantly warm, they have little apprehenſion of being uncomfortably cold in any part of their bodies. A hint, by the way, in favour of placing a grate or ſtove low, a circumſtance ſeldom conſidered; but of much more conſequence than would be believed, without an actual experiment, as I was myſelf fully convinced, by being under the neceſſity, in a beſieged town, to make my coal fire immediately on the hearth, for want of a ſtove or grate.

Let us now ſuppoſe the earth about this bonfire to be gradually raiſed, and the higher as more remote, until the cavity became ſuch as would be made by ſinking a loaf of ſugar, with its ſmall end downward into clay. There can be no doubt but that the current of hot air would remain in the center as before, and that the air to ſupply it, would deſcend to the fire by the ſides of the cavity all around. In the ſame manner, if we place a ſmall lamp at the bottom of one of thoſe tall cylindrical glaſſes, uſed as ſhew-glaſſes by the perfumers and confectioners; and place the glaſs upright, the current of hot air will be directly over the lamp, in whatever part of the bottom it is placed, and in all other parts there will be a current downward to ſupply the former. If the lamp is placed in the middle of the glaſs, unleſs the air of the room is perfectly ſtill, the

flame of the lamp will be ſeen in continual agitation: but if it be placed near the ſide of the glaſs, or the glaſs be inclined to one ſide, the flame will be much more regular and quiet. In the firſt caſe, the limits of the columns, not being ſo well defined, any little irregularity in the motion of the air, as it enters the top of the glaſs, confounds and intermixes the two currents; but when the glaſs is inclined, or the lamp placed on one ſide of it, the light hot air attaches itſelf to the upper ſurface, from the preſſure of the more denſe and heavy deſcending air, which enters the top, at the lower ſide, or the ſide oppoſite to that where the lamp is placed, and the flame being then more regularly ſupplied with air, in a better defined and more diſtinct current, is ſeen to increaſe immediately in length and ſteadineſs.

Now a chimney in a room may be ſuppoſed to reſemble this glaſs, with the lamp at the bottom repreſenting the fire; for although air enters all rooms through the cracks of the doors, windows, &c. yet the velocity of the wind, at thoſe paſſages, ſhews that the air in the room is leſs heavy than that without the houſe; whenever therefore the chimney has not a good draught, the ſmoke has not a ſufficient tendency to riſe ſometimes, without an additional ſupply, by opening a window, more or leſs; in conſequence of which the balance

lance is determined in favour of the aſcent in the chimney.

To diſcover the cauſe of this bad draught, as it is called, it is to be conſidered, that in the ſame manner as the lamp will burn at the bottom of the high glaſs, will a fire burn and ſmoke aſcend in a chimney, even in a room perfectly cloſe, provided the flue of the chimney is formed of the ſame bigneſs all the way, or larger at the top.

From this experiment then of the glaſs, we may eaſily deduce the proper form of the flue. It is evident, that the worſt form, or rather direction, for the form is immaterial, is when it changes its courſe in angles; for in this circumſtance conſiſts almoſt the whole myſtery of ſmoking chimnies. The next diſadvantageous direction is, when they are built directly perpendicular; but the beſt is when the flue is perfectly ſtraight, but declining from the perpendicular, and the more ſo the better.

When the direction is irregular, or in any degree zigzag, it is plain that the hot air, when it has arrived at one of theſe angles or protube rances, muſt ſhoot acroſs the flue, that it may be ſtill on the upper ſide of that part where it is paſſing, at which time it muſt diſturb and mix with

with the cold air; which, if the flue is equally large, or larger at the top, and the room rather close, will be descending, as in the experiment; or with what may be forced down by an irregular current. In consequence of which mixture, no part will have a sufficient tendency to ascend, and the balance will be turned in favour of the external air, at the time of an eddy, and it will press the whole together down the flue, and of course bring the smoke back into the room. If the wind be high and the eddy strong, the smoke will pass out into the room, in a continued current, till the blast be over; but, if the wind be more moderate, the smoke will hover about the mantel-bar, as if undetermined which way to go.

I have above supposed the flue to be of a uniform bigness, or larger at the top, in which cases the smoke would certainly ascend in the manner I have supposed, although the room were perfectly close. We have then advanced a step in our general investigation; and, as I hope, without confusion or fatigue.

To return to an experiment. If a glass be made in form of a cone or sugar loaf, instead of a cylinder, like the former glass, with only a small hole in its apex, or little end, and the glass placed

on

on the great end, with the lamp at the bottom, it will then burn very faintly, if not go out entirely, for want of a ſupply of freſh air; the air within the glaſs being then in a ſtate called aduſt, or burnt air, which I ſhall have occaſion to mention again hereafter; for the ſmall hole at the top does not allow a ſufficient diſtinction of cold and hot columns, as the former cylindrical glaſs did, and there is conſequently little or no circulation. In the ſame manner, if we fill the cylindrical glaſs with water, and turn it bottom upwards, the water will all run out, although there is the whole atmoſphere preſſing upon it, becauſe that preſſure, notwithſtanding all our endeavours, will be unequal; but if we put the mouth of this glaſs under water, none will run out, becauſe no air can enter to ſupply its place. If we fill the conical glaſs with water, and turn it up as the other, not a drop will run out at the ſmall hole, and this, although the hole is not ſo ſmall as to be capillary; becauſe in this caſe, the horizontal plane of the hole is ſo ſmall, that a ſufficient inequality of preſſure will not take place to overcome even the natural tenacity of the water.

We are now to apply theſe laſt experiments and obſervations to the actual ſtate of rooms and chimnies. The top of the flue is generally ſmall, in conſequence of the uſe of the earthen pots on the

the top of chimnies, which pots are clearly uſeful, ſince they hold little wind themſelves, and by removing the aperture of the flue to a diſtance from the broad chimney, leave room for the air to expand before it reaches the aperture, and thereby leſſen its tendency to paſs down the flue by expanſion. The air alſo is chiefly ſupplied from below, even when no pot is uſed, little air paſſing downward in a common chimney, as in the cylindrical glaſs; but when the wind is ſtrong, and there is any thing to cauſe an eddy; although the paſſage be narrowed by the pot, and ſo the velocity of the air at the aperture greater and more powerful, yet we find, by experience, that the chimney will ſometimes ſmoke; the greater part of the aperture being occupied by the deſcending air, and this, when the wind is ſtrong in a moderate degree; but the whole is indiſcriminately forced down, when this eddy is ſtill more powerful.

When the whole column is thus forced down, and the air of the room more condenſed; as ſoon as this temporary blaſt is over, we obſerve the ſmoke near the fire-place returning up the chimney with double velocity; the air in the room being then at liberty to expand. The pots on the top being however clearly uſeful, *and very materially ſo*; it remains to inquire, what meaſures

can

can be taken for the ſeveral purpoſes of conveying the ſmoke, and increaſing the warmth of the room in conjunction with them.

I am now to allow all that the Count has advanced reſpecting the ſmallneſs of the fire-place, the divergency of the jambs, and the conſtruction of the throat, excepting only the propriety of placing the throat ſo near the fire: but, as the general conſtruction of the fire-place, without regard to the throat, gives the heat to the air, by obliging it to paſs near to the fire, it remains for me to explain the reaſon why his perpendicular jambs, &c. are uſeful, and then to propoſe, on the principle, of which he does not appear to have a clear conception, ſuch a conſtruction reſpecting the throat as is much more effectual.

In order then to enforce the propriety of raiſing the throat, inſtead of ſinking it, and at the ſame time, the uſefulneſs of the diverging jambs, and prove their utility from experience as well as by theory, it will not be amiſs to give the hiſtory of their origin in America, where they have been long in uſe.

In early times in America, wood being plentiful and labour high, it was uſual to cut their wood for the fire from three to ſix feet long: this

required a large fire-place, and accordingly they were generally built ſo, even in the beſt rooms in good houſes; many of them in the ſame manner as the fire-places in the country in England, with a ſeat in each ſide-wall or jamb, and the whole was generally white-waſhed. Now, as wood makes much more blaze, and warms much more at a diſtance, or ſends out more radiant heat, as the Count terms it, than coal; probably from the leſſer denſity of its texture; it naturally happened, that the tendency of theſe white walls to reflect the radiant heat, was noticed and found to be conſiderable in America, while the dull coal fire in England never had given that intimation. Accordingly, as wood became leſs plentiful, the propriety of reducing the fire-place became obvious. They then built a ſmall fire place within thoſe large ones, and conforming in part to the old practiſe, kept the front ſtill wide, but narrowed them more at the back. This anſwered the purpoſe of allowing the ſight and the direct influence of the fire to a greater number of perſons, and at the ſame time, thoſe diverging ſides, which obtained the appropriate name of *flaring jambs*, being ſtill kept white, reflected the radiant heat more completely into the room. This I advance as a probable conjecture only; but, if the expreſſion *flaring jambs* is known in England, it muſt have been carried over by the

firſt ſettlers, and the conſtruction originally begun in England.

That the Count however believes himſelf to be, and that he is in fact a real inventor of them, I have not the ſmalleſt doubt, for his character is far ſuperior to ſuch a pretenſion; but being but young when he left America, and having ſpent the greater part of his time there, as I believe, in the country, where wood ſtill remained plentiful; it may well be ſuppoſed that this matter had not engaged his attention; and I am perſuaded, that it will gratify him much to find and believe, that his propoſal has been ſo long confirmed by experience. Thoſe flaring jambs, indeed, by whatever name called, are not abſolutely confined to America; for I have myſelf ſeen them in England; and no doubt, there are many inſtances of a ſmall fire-place built within a larger, and in general the whole conſtruction as directed by the Count, though, perhaps, in few inſtances, if any, to ſo much advantage: nor were they ſo well conſtructed in America, although, as I have ſtated on the ſame principle; the throat being ſeldom ſo ſmall, or the fire-place in general ſo much reduced.

However aware we may be of the Count's rapidity, it is not a little wonderful to find him,

page 362, deſcribing under the name of a hollow truncated cone or pyramid, with great accuracy, an invention which, although he allows that it is not new, yet, he ſays, has not often been put in practice; which appears to be nearly thoſe pots to be found on almoſt every chimney in London, changed externally in dimenſions, but this much for the worſe, in conſequence of his confounding the glancing of a ſolid body, after ſtriking another obliquely with the motion of an elaſtic fluid in the ſame caſe; which, as ſoon as relieved from the obſtacle, expands in all directions. He adds, that where ſeveral flues come out near each other, or in the ſame ſtack of chimnies, the form of a pyramid will be better than that of a cone for theſe covers; but I muſt queſtion this, ſince the air will more eaſily paſs a cone than a pyramid. I have obſerved, that theſe pots are found by experience to be very uſeful, and given two diſtinct reaſons for it; one, that the wind by that means has leſs tendency to force itſelf down the flue; and the other, that the flue is thereby made ſmaller, and the velocity of the air, and conſequently its power of reſiſtance thereby increaſed, by which it is better able to balance any moderate tendency of the air to paſs down; that the velocity of the air will be greater through the aperture of a pot than the larger flue, I will exemplify by the pipes in the ſtreet. When a paſ-

ſage

ſage is opened up a pipe, in caſe of fire, the water ſpouts up about a foot; but if you put your foot on it, ſo as partly to ſtop the hole, it will riſe five feet, or more. This ſmall paſſage however brings the caſe of a chimney to reſemble the conical glaſs in our experiment, with the ſmall end upward, and a ſmall hole in that end; in which caſe, I have obſerved, that the lamp at the bottom will nearly or quite go out, for want of a ſupply of freſh air. So in caſe of a chimney, or rather flue, if it is nearly of a bigneſs all the way, or larger at the top, and the fire but ſmall in proportion to the diameter of the flue; the ſmoke would go up, and the fire be ſupplied with freſh air, by a diſtinct current downward, and the chimney not ſmoke, although the room were perfectly cloſe; but otherwiſe, a freſh ſupply from below becomes indiſpenſible. When, therefore, a pot is placed on the top, as is uſual, there can be little if any ſupply of air, in the manner of our experiment of the glaſs cylinder, from above; but I have explained the circumſtances that would take place were the chimney all the way of a bigneſs, in order that I may be the better underſtood, when I come to deſcribe the method of counteracting the effect of an eddy, or extraordinary blaſt of air downward.

The reaſon for the ſmallneſs of the fire-place, chiefly is, that the air may be made to paſs nearer

nearer to, and be more expoſed to the fire, that it may be more heated and rarified; and on the ſame principle, if the throat is high, the air and vapour will be longer expoſed to the heat of the fire. But there is another very important uſe in carrying up the back and jambs, as the Count directs, which he ſcarcely hints at; *viz.* that the current of hot air or ſmoke is determined to a particular part of the flue in a diſtinct column, as in the cylindrical glaſs in the experiment; and when at any time the wind forces itſelf down the flue, finding moſt reſiſtance in the direction of this diſtinct column, before it arrives at the throat, it divides itſelf to all other parts of the cavity, leaving a paſſage for the hot air from the throat; and is really condenſed and lodged during the blaſt, over the internal chimney, around the throat, juſt as if laid on a ſhelf. For this reaſon, the Count very properly cautions againſt carrying up the top of the back and ſides, in a ſloping manner, to meet the old wall, but directs them to be horizontal.

This conſtruction, ſo far as it goes, is founded on principle, and is very uſeful, but is far indeed from taking the utmoſt advantage of the principle: for, when that is clearly underſtood, it appears evidently better to conſtruct, not only an internal fire-place, but to convey my idea in the feweſt words, and in the moſt ſimple manner, to build

build a little chimney in the great one, and the larger the great chimney is up to the pot on the top, and the ſmaller the little chimney in proportion, ſo much the more uniform will be the draught. To explain this. I obſerved before, that when the ſmoke is forced into the room by a ſtrong blaſt down the chimney, it of courſe increaſes the denſity of the air in the room, and that, as ſoon as that blaſt ceaſes, the air and ſmoke return up the flue with increaſed velocity; as every perſon muſt have obſerved by the ſmoke near the mantel-bar. When, therefore, the internal chimney is built, as directed by the Count, there is in a degree the ſame proceſs within the flue, by the expanſion of the air accumulated over the jambs. Is it not then obvious, that the more room there is within the chimney for the air to be thus depoſited, during the continuance of ſuch irregular and temporary blaſt, the leſs will the paſſage of the hot air in the throat be obſtructed. This addition to the Count's directions is not new, for there were ſome ſuch in America, and I ſpent the greater part of my earlier life in a room thus provided. It is alſo particularly, and very clearly deſcribed, in a letter from Dr. Ruſhton to Dr. Franklin, to be found in the Annual Regiſter for 1787. It was an original thought, I have no doubt, in the Doctor, as the other of the flaring jambs was in Count Rumford.

Since

Since Dr. Ruſhton has ſo clearly deſcribed it, though he has not explained the principle, in that paper at leaſt; I will only ſay in general, that having built the lower part of the fire-place, as the Count directs, it ſhould then be continued upward, from a little above the mantel-bar, by converging, or bringing toward each other the back and ſides, and the front or breaſt alſo, by running a bar of iron within, and a little higher than the mantel-bar, and ſo all around to lay the bricks upon; and thus the four ſides are to be continued upward, approaching each other, until the throat be left juſt ſufficient for the paſſage of the ſweeper. The little internal chimney is then to be continued conſiderably higher, by running up a large iron or tin tube, ſimilar to the pots uſed on the top of chimnies, except that it will be a ſquare pyramid, inſtead of being round or conical. This tin ſhould fit the throat as left for the ſweeper, as cloſely as poſſible; and be ſupported in its place, by two ſmall iron bars, running acroſs under its lower end, and looſely let into the brick work at each end; which bars may be taken out, and the tin funnel removed, as occaſion to ſweep the chimney ſhall require. There will then be a vacant ſpace all round the internal chimney, as far down nearly as the mantel-bar. The room referred to above, in which I formerly ſpent ſo much time, was uncommonly warm,

warm, nor did I ever obſerve the ſmalleſt tendency in the chimney, which was alſo in general conſtructed as propoſed by Count Rumford, with this very material addition; to ſmoke in any degree, let the wind blow from whatever quarter, or with the greateſt violence; but I have known thoſe built on the Count's plan merely, ſmoke intolerably, though it very rarely happens, and then, probably, from the zigzag direction of the flue, or the very peculiarly unfavourable ſituation of a neighbouring building, or perhaps the two cauſes united.

As to the neceſſity, that the walls of the fireplace ſhould be perpendicular, ſo much inſiſted on by the Count, it is of no conſequence, any farther, than that by this means the throat becomes ſmaller in proportion to the ſpace above it; and ſo it approaches nearer to the beſt principle—of building a ſmall chimney in a large one, than if they fell back as they were raiſed, toward the old wall. It is ſurely more agreeable to the eye to be perpendicular, elſe they might as well approach each other gradually, from the hearth upwards, in the manner of the arches of London Bridge; for there is ſurely no charm in a perpendicular, in this inſtance at leaſt. A cannon ball, it is certain, would be turned out of its direction by a quire of paper, if it ſtruck it obliquely;

ſurely then an elaſtic fluid would not be obſtinate. To this purpoſe let me deſcribe a very pretty ſtove, invented by Dr. Franklin, and uſed in his bed room, which he told me he conſidered as a toy, and did not propoſe to publiſh. The front of the chimney was completely manteled or ſtopped, but there was a canal, about three inches ſquare, in the hearth, running under the middle of the mantel, and opening into the chimney. On the outſide this canal was covered, except a hole of about three inches diameter, over which was ſet a ſtone cylinder, of about a foot diameter, and two feet high, having a hole through its whole length, anſwering to the hole in the canal; and upon the top of this ſtone was ſet a hollow iron body, formed exactly like a pine apple, with leaves, &c. In the center of the pine was the grate, and the top with the leaves being ſeparate, in the manner a pine is uſually cut in that part, the coal was put into the pine, and the air was ſupplied for the draught through a number of ſmall holes between the leaves, not to be eaſily noticed. Now in this inſtance, as in many others, the ſmoke moved at firſt perpendicularly, it is true, but it was perpendicularly downward.

As to the throat of the internal chimney, being near the fire—let us ſuppoſe the fire ſo high above the hearth as to be on a level with the

mantel

mantel-bar, and the throat ten feet above it, it is evident, that the ſpecific gravity of a column of the atmoſphere, of which this ten feet makes a part, would be leſs than the ſpecific gravity of a column of the ſame ſize, were the throat but two feet above the fire, in conſequence not only of its length, but its being longer expoſed to the fire. A great point to be aimed at is, to oblige what air does paſs from the room up the chimney, to paſs as near as poſſible to the fire, that it may be rarified and made ſpecifically lighter. In this, therefore, on the Count's own conſtruction and principles, without regard to farther advantages, he is, I think, completely and very materially miſtaken; and I may add, that on any principle the Count has explained, it were much better that there were no throat at all, properly ſpeaking, but that the flue were carried quite to the top, of the ſame ſize as he would have the throat to be. The chimney might be ſwept, by other methods, equally or perhaps more effectual, and more conſiſtent with humanity. But it is in vain to plead *for the lives of a few children*; cuſtom has eſtabliſhed the preſent mode, and it will not be changed.

That the air, although tranſparent, is warmed by the radiant heat, cannot, I think, be doubted, although we allow that this effect is ſmall, in proportion to its tranſparency; but this diſcuſſion.

would be very immaterial, for either air, or vapour of ſome ſort from the fuel, is always contiguous to the hot coals, and ſurely the Count will allow, that air may receive heat in *this* manner. But that the particles of air and of radiant heat have *ſome* effect on each other, is plain, from the refraction of the atmoſphere.

When the fire-place and throat of the chimney are ſmall, as directed, little air actually paſſes up the flue from the room, for the fuel conſtantly ſupplies a quantity of very hot elaſtic vapour or ſteam, which being on the whole lighter even than warm air, by its expanſive power occupies the paſſage. It is true, that if the throat is very near the fire, the hot bricks will expand the vapour and air as it paſſes; but then, it is not ſo long acted on by the fire itſelf, which is much more hot; beſides, that the length of the column ſo rarified is diminiſhed in proportion.

It is a very general fault in argument, that inſtances and compariſons, which are uſeful to illuſtrate the ſubject, are not taken ſufficiently ſtrong and ſtriking, and often need as much explanation as the ſubject they are produced to explain. To prove therefore the propriety of this idea, of building a ſmall chimney in a large one, let us, without intending to be ludicrous, ſuppoſe a ſhip

ſtove

ſtove to be placed in a cellar, and the ſtraight iron flue to riſe juſt above the floor of the parlour, through a hole in the center of it. The room will then repreſent part of a chimney, for the ſmoke will paſs up the ſtove flue, through the parlour, and up the flue of that room. Let us then ſuppoſe the iron flue to be five feet long: it is clear that with a certain fire the ſmoke will aſcend this flue, with a velocity proportioned to the comparative gravity of that column, and a column of air in its natural ſtate. Let us next ſuppoſe a tendency of the air to paſs down the flue of the parlour chimney; it is very evident, that in proportion to the bigneſs of the room, it will be longer before the aſcent in the ſhip ſtove from the cellar is overpowered, and the ſmoke forced out below into the cellar; and if we ſuppoſe the flue of the ſhip ſtove to be twice ſo long, ſo as to reach half way up to the ceiling of the parlour, the column of light air, and its tendency to riſe, will be alſo doubled; and it would be double the time before the ſmoke would be forced out below; during which time the eddy may be exhauſted, and the draught be ſufficient to overcome it; and of courſe no ſmoke at all be forced out into the cellar.

Having related one probable origin, at leaſt, of the conſtruction the Count recommends—explained

plained the principles on which it is founded—and pointed out an additional improvement on the ſame principle—I am now to propoſe and explain a method of promoting the aſcent of the ſmoke, and the warmth of the room; which, although not new in principle, may be much better diſpoſed than has yet been practiſed; and which, I think, will be generally agreeable, if attended to, ſince the fire-place below the mantel-bar may remain as at preſent conſtructed, and the room ſufficiently warmed, notwithſtanding the loſs of the reflected radiant heat from the jambs. There are two objections to that conſtruction, which have ſome weight; one, that in paſſing quick along the front of it, the ſmoke is frequently drawn out into the room; and the other, that the dirty ſmoked jambs are too apparent, and make too great a part of the room to be admitted in an elegant houſe. The firſt of theſe objections I know to be real by experience, but the other I advance with diffidence, as there may poſſibly be methods of obviating it.

It is well known, that many years paſt, Dr. Franklin contrived a ſtove, the principle of which was, that the air to ſupply the draught was admitted from without doors, through a tube, to paſs firſt into the ſtove, without any communication

tion with the room, and after circulating through hot iron cavities, to be admitted into the room through a hole in one of the upper corners of the ſtove, in the front, thence to riſe and ſpread over the whole room, and at length paſs, as uſual, into the open fire-place, and up the chimney. Theſe ſtoves, which warmed a room ſurpriſingly in all parts, as they prevented, in a great meaſure, a draught of cold air by the windows and doors, are ſtill uſed in Pennſilvania in ſome large working rooms.

A Mr. Sharp, and others, have made improvements at different times in the elegance, though not in the principle of them, and attempted to introduce them in London; but air, by paſſing hot iron, and *perhaps* any other hot ſubſtance, is found to be diſagreeable, if not unhealthy; but this, not ſo much perhaps by roaſting duſt, as the Count ſuppoſes, but by producing in caſe of iron, in conjunction with the moiſture in the air, a quantity of inflammable air; for ſteam and red-hot iron, it is well known, produce inflammable air, and a balloon may be filled by that means; and perhaps a ſtrong heat *only* may affect that principle in the air, which is neceſſary to ſupport both fire and animal life, producing what is termed, aduſt or burnt air, both of which have been ſuppoſed unfit for reſpiration; the former

moſt

moſt certainly is ſo, but reſpecting the latter it may be doubted, for it ſeems more probable that this injury ariſes from the addition of other matter to the pure air, rather than from heat ſimply; the fact ſeems to be certain, however inadequate the knowledge we have of the nature of heat may be to the ſolution; that ſuch air is not equally ſalutary with the common air, which has not been through this proceſs.

The way is now, I preſume, prepared to deſcribe my own propoſal, and if it ſhould not appear to be new, in diſpoſition and convenience, though I am well aware not in principle, Count Rumford, Dr. Ruſhton, and Mr. Sharp, are at full liberty to return my compliment, for it certainly is difficult to know what is new on ſuch ſubjects, as every one muſt have obſerved, who poſſeſſes any fancy or invention.

At a lodging I had in London, ſome years paſt, I obſerved a fire-place in the ſhop, which was never uſed, and found that the flue of it paſſed directly behind mine: when it occured to me, to make a hole through the back of my fire-place, at the hearth, into that flue, by which means the draught of my flue would be ſupplied with air. Accordingly I obtained permiſſion, and made the paſſage about three inches ſquare,

and

and found it to anſwer the firſt intention completely. The air of the room was changed, in the proportion that this hole bore to the united bigneſs of all the other apertures, by which air could enter the room, and the air of the room might be changed, and the degree of warmth regulated, as I was diſpoſed; without being injured by paſſing through any hot ſubſtance whatever.

This method may be uſed by itſelf, or added to the others, as each perſon may chuſe, and, in ſome caſes no doubt, all poſſible methods united, would be deſirable. What I propoſe then is, that when a new chimney is to be built, a ſmall flue, about three or four inches ſquare, totally unconnected with thoſe for ſmoke, be brought up in the chimney, from the cellar or other low room, where it may have, either immediately, or by means of a tube, communication with the external air: and that there be a branch from this air flue, to the hearth of every fire-place.

This branch then to be continued, and form a ſquare canal in the hearth, directly under the mantel-bar, the whole breadth of the front of the fire-place; and to be covered with an iron, braſs, or marble plate, having a ſlit in the middle,

of ſuch a width, that taken together, it may be a little leſs than the flue; of courſe about half an inch wide; which will have the ſame effect, with regard to the draught, when open, as the opening a window of the ſame width with the front of the fire-place, half an inch. This ſlit or paſſage in the plate, to be covered with an iron or braſs plate, in the manner of a door, and to turn on hinges, to be placed on that ſide of it next to the room, by which means the paſſage of the air may be regulated, and more or leſs admitted, as the temperature of the room may require.

The general idea muſt, I think, be clearly underſtood; but there is another important and very pleaſing uſe, to which it may be applied, which is, the kindling the fire, or keeping up the brilliancy or intenſity of it, to any degree deſired; as thus, let the front canal juſt deſcribed, be continued from its middle, at right angles, directly under the middle of the grate or ſtove, and this part covered entirely, except a hole perhaps about two inches diameter, under the center of the grate, and this hole to have a cover as before for the front canal, to open or ſhut it as deſired. We are then to be provided with a ſhort tube, to be placed occaſionally over this hole, perpendicularly, to convey the air up to the grate. The fire is to be begun directly over this tube, which will convey

convey a conſtant ſtream of air, and kindle the fire with the utmoſt eaſe; after which, if deſired, the tube may be removed and put in its place, out of view, and the hole ſtopped. During this time, the front part muſt be ſtopped, but when opened, a ſheet of air will be uniformly and conſtantly admitted, and the warmth of the room, with little or no alteration of the fire, may be completely regulated. By means of the ſmall tube, as I have hinted, the difficulty of keeping a ſmall quantity of coal properly inflamed, may be entirely obviated, the reaſon of which difficulty the Count has not explained, but this very circumſtance is ſufficient to point out, namely, the want of a courſe of interſtices or cavities, between the coals, to make a draught of freſh air. This experiment, as I before obſerved, I tried imperfectly, about ten years paſt, and found the ſtream of air to be effectual to every purpoſe; the fire might be kindled with the utmoſt eaſe, and the chimney never ſmoked. While writing this Eſſay, I have heard, that the Count has propoſed a conſtruction of a ſtove, by means of which the air of the room is to do this part of blowing the fire.

The reaſon of my directing the canal to be made along the whole front of the hearth is, that otherwiſe the draught being ſupplied from

within the fire place, the ſmoke would be apt to be brought out into the room, by a perſon's paſſing quick along before the fire, there being but little current from the room; but by this diſpoſition, it is the ſame, in effect, as if the whole came from the room.

To adapt this propoſal to chimnies already built, with the leaſt trouble and expence, will in ſome caſes require conſideration and advice; but the chimnies in London, being almoſt univerſally built againſt a party wall, and in the country againſt one of the ſides of the houſe; it can ſeldom be difficult. For in caſe of the party wall, it is only to make a channel in the wall, from each fire-place hearth horizontally, and juſt above the floor of the room, until it meets the external wall, and then to paſs through it, and open to the external air. In this channel a tin tube ſhould be placed, and entirely concealed. When the chimney is built againſt an external wall, the buſineſs is ſtill more ſimple and eaſy; for then, it is merely to make a hole through the wall on a level with the hearth. Other caſes muſt be left to the ingenuity of the workman, and the choice of the proprietor of the houſe.

It is difficult to determine whether the fire-places recommended by the Count, with the improvement

provement added, of raiſing the throat, or, as I have expreſſed it, building a little chimney in a large one, or the method of an air flue, would be the moſt effectual to the purpoſes deſired. At preſent it appears to me, that the little chimney would be moſt efficacious with regard to ſmoke, and the air flue to warmth. But if one only be adopted, the vote will ſurely be given in favour of the air flue, by all the pretty maids, and other fire-makers in the kingdom, let the philoſophers think as they pleaſe.

On the whole, were I to build or fit up an elegant houſe, the chimney places below the mantel-bar ſhould be conſtructed as they are at preſent, but ſmaller than they generally are; for I ſuſpect that thoſe flaring jambs cannot be kept clean, and will have a dirty variegated appearance, notwithſtanding the utmoſt care. Marble would ſtain yellow; and whitewaſh, as recommended, would be too ordinary; the firſt would not conſiſt with neatneſs, nor the latter with elegance.

I would put in thoſe fire places a handſome ſtove, nearly on the principle and conſtruction of the common Bath ſtove.

I would carry up the back, breaſt, and ſides of the fire-place, from the mantel-bar, meerly by means

means of a ſquare pyramid or obeliſk of thin iron, fitting the cavity nicely at the bottom, and about ten inches ſquare at the top, more or leſs, according to the ſize of the ſtove and room, and running up into the chimney as far as poſſible, to allow of its being taken down occaſionally to ſweep; of courſe, it might be about as long as the mantel-bar is high above the hearth; to be ſupported in its place by pieces of iron, running looſely into holes in the brick-work, on every ſide; and no one will be ſurpriſed, when to this ſecurity againſt ſmoke, I add my own propoſal—to prevent ſmoking—to increaſe and regulate the warmth of the room—and to kindle the fire.

This addition of an iron pyramid, by way of internal chimney, may be made to thoſe already built, as propoſed by the Count. In no caſe, however, ſhould they ſtand exactly perpendicular, but incline in the oppoſite direction to the flue, for the reaſon explained in the experiment of the ſhew-glaſs; or, if the flue be perpendicular, to any quarter in a ſmall degree, that the current upward may be on one ſide, and therefore more diſtinct from what may be deſcending in conſequence of an eddy.

In regard to regiſter and other iron ſtoves, now in uſe, I do not feel that antipathy to them which the

the Count expreſſes; but, ſurely, many of them are abſurd in principle; ſuch as that which fills the whole front of the chimney, except a round aperture in the middle, juſt allowing a ſight of the fire; and, in general, the nearer they form the fire-place to thoſe recommended by the Count, they are certainly to be preferred; but then, the conſiderable advantage of the radiant heat, reflected from white flaring jambs, is loſt; in all caſes it is a needleſs expence; while the ſale of one of them would probably pay all the expence of diſpoſing things to much greater advantage. In the beſt and moſt expenſive rooms, I would recommend the form of the fire-place propoſed by the Count, with the additions, provided the jambs can be kept neat and elegant, in conformity to the general appearance of the room.

In a note, in page 346, we find the Count much delighted, with the diſcovery of a clear and undoubted proof of the great effect of that principle which he had before obſerved, when arguing againſt iron ſtoves, that he could have no conception of; and great hopes are *here* given of improvements in conſequence, if not ſo explicitly, in page 314. He will not, I hope, be offended, if I take the liberty of paſſing one more joke on this rapidity of improvement. A gentleman, with whom he is well acquainted, informed me, that

not

not long ſince he tried an experiment of bringing forward the back of his kitchen chimney, and that the heat thrown out was very conſiderable, and the bricks, where the flame ſtruck, would, as the Count obſerves, become red hot; but found it neceſſary to take it down again, as it was in the way of the cooking utenſils; beſides, that the heat was quite intolerable to the cook, in ſome of her operations about the fire. Should the Count think that it might, however, be uſeful in a dining-room, I may obſerve, that however he may manage the principle, this particular conſtruction will not be found to be deſirable. A gentleman, who is now a reſpectable clergyman in the north of England, tried this experiment in his room, when we were at college together in America, more than thirty years ago, and I followed his example; but we found, that bringing the ſmoke ſo near the front of the chimney, expoſed it to be brought out into the room, whenever a perſon paſſed ſuddenly along the front; we therefore abandoned the idea, although in general found to be uſeful.

ON

# *EXTINGUISHING FIRES.*

MY imagination having become fatigued with the ſubject of *making fires*, and perhaps reflected by the flaring jambs, like the radiant heat; at laſt fixed on the equally uſeful inquiry, into the beſt method of *putting them out*. I have then to propoſe a manner of preparing a houſe or ſhip, at little expence, in ſuch a manner that a fire may, I am perſuaded, be extinguiſhed with the utmoſt eaſe and certainty.

Let there be provided an hollow copper ball or ſphere, three or four inches diameter for large rooms, and proportionably leſs for ſmall rooms, ſtair-caſes, cloſets, &c. Let thoſe balls be pierced with a proper number of ſmall holes, and be placed at the top of each apartment, and in the middle of it, and there be ſcrewed to the end of a ſmall tube, of any metal, which is to paſs between the floor and the ceiling, and ſo through the external wall of the houſe, to a convenient

part of the front, or the deck of a ſhip; and if a little additional expence be not regarded, let them all be brought to the ſame place, through the wall, and there arranged in a line, cloſe together, like the keys of a harpſicord; and be each fitted with a ſtopper, to ſcrew on; and let the name of the room to which each tube belongs be engraved on it; and, perhaps, where the apartments are ſmall, the ſame tube may branch off to ſeveral of them.

At preſent, an immenſe quantity of water is thrown into a houſe on fire, to no ſort of good purpoſe; and we are ſo much in the habit of ſeeing it done, that it is not conſidered how very ſmall a quantity would be ſufficient, if properly applied.

When, therefore, the engine, water, &c. are ready (until which time no door or window ſhould be left open) the people of the houſe are to inform the maſter of the engine which particular apartment the fire is in; when the pipe of the engine is to be ſcrewed to the proper place, and the engine played; the water will then be thrown in a violent ſhower to every part of the apartment, through the holes in the ball at the top, and the fire extinguiſhed in a moment.

In

In a room of any conſequence, thoſe balls might be gilded, and made rather ornamental, than a deformity.

It is generally impoſſible to apply water to the whole apartment on fire. If windows are opened for the purpoſe, the free admiſſion of air, the chimney being open, makes a furnace of the houſe; and often increaſes the fire much more than the water thrown in, as at preſent, tends to extinguiſh it; and the firſt houſe that takes fire is very generally deſtroyed; the preſent method tending only to prevent its ſpreading, rather than to put it out.

If a fire takes place, for inſtance, in a garret, or other high apartment, the ſmoke prevents the pipe from being carried up in the inſide, and the water can only be thrown upon the top of the houſe, in order to leſſen the violence of the flames when it ſhall make its way through; or into the lower rooms to check its progreſs downward; but not a drop is applied to the fire immediately, and the men think, that they merit greatly by ſaving a little of the timber, earning their porter, and amuſing the idle ſpectators. But even this is ineffectually done oftentimes, from the force of the wind, and the natural tendency of the water

to divide into drops, when thrown with violence to a great height; for there is no engine in London that would throw a drop of water two hundred feet high, let the force applied to it be ever ſo great. But, in the method propoſed, the water being included in a tube will riſe to any reaſonable height, and produce the ſame effect as in a parlour. In the inſtance of the ſhip of the line, not long ſince, at Portſmouth, the cabin was found to be on fire; and, on opening the door, it was found to be totally impracticable to apply water, on account of the violence of the flame and ſmoke; but in this method the door would have remained ſhut, and the pipe of the engine being applied with deliberation to the pipe on the deck, a few buckets of water thrown in, and thus diſperſed to every part, could not have failed to extinguiſh it before the boatſwain could have called—Jack Robinſon!

In the inſtance of the fire at Covent Garden church, it was impoſſible to apply water, whereas if the church-ſteeple had been provided in this manner, it would have been extinguiſhed with as much eaſe as if it had happened in the veſtry.

Should this be the firſt publication of this propoſal, and the public ſhould approve of it, I ſhall be

be happy to ſee it executed, ſaving the right I may have by law.

---

Since this paper has been at the preſs, a gentleman, whom I accidentally met at the office, was ſo obliging as to offer to lend me a volume, containing a paper on this ſubject, by a Mr. Clavering—one by Dr. Franklin, and a third, the paper of Dr. Ruſhton, I have referred to. The two firſt I never ſaw, but am happy to find that my own requires no *material* alteration or addition, and I have made none at all. The Dr. was very old when he wrote this paper, and at ſea; and it was deſigned only as a ſummary of what he could recollect on the ſubject, at the deſire of a friend.

Mr. Clavering, a builder, appears to have been a man of ingenuity, and to have taken pains to inform himſelf, but was not, I think, ſufficiently grounded in the general principles of natural philoſophy to avoid miſtakes. He recommends a round flue; but Dr. Franklin thinks the form of the flue immaterial. A ſquare flue is probably moſt convenient for the ſweeper. Mr. Clavering diſputes the propriety of the pots on the top, and one of his arguments is, that a ſweeper getting

ting up into one of them, rolled from the top of the houſe to the bottom, without much injury. Had he beat out his brains, the argument would have been ſtronger, as there would have been reaſon to fear, that others having brains, would do the ſame.